8 METHODS FOR PROTECTING COAL MINERS

The following methods should be used to protect miners from the adverse health effects of exposure to respirable coal mine dust and respirable crystalline silica:

- Informing workers about hazards
- Establishing written emergency procedures
- Using engineering controls, work practices, and personal protective equipment (including respiratory protection when dust control equipment is being installed, maintained, or repaired)
- Monitoring exposures
- Conducting medical screening and surveillance
- Encouraging smoking cessation
- Maintaining medical records

8.1 INFORMING WORKERS ABOUT HAZARDS

8.1.1 Training Programs

Employers should establish a training program for all coal miners and other workers exposed to respirable coal mine dust and respirable crystalline silica. Training should be provided whenever a new job is assigned, and workers should be informed about the health and safety hazards of the worksite. Training should include information about measures workers can take to protect themselves from exposure to respirable dust (e.g., the use of appropriate work practices, emergency procedures, and personal protective equipment--including the emergency use of respiratory protective equipment).

8.1.2 Posting

All warning signs should be printed in both English and the predominant language of workers who do not read English. Workers who cannot read posted signs should be identified so that they may receive information about hazardous areas and be informed of the instructions printed on the signs.

8.2 ESTABLISHING WRITTEN EMERGENCY PROCEDURES

The employer should formulate a set of written procedures covering fire, explosion, asphyxiation, and any other foreseeable emergency that may arise during coal mining or in other occupations where workers are exposed to respirable coal dust. All potentially affected workers should receive regular training in fire or emergency evacuation procedures and the proper use of self-contained self-rescuer (SCSR) and other rescue and evacuation equipment. Selected workers should be given training in first aid, cardiopulmonary resuscitation, and fire control. Procedures should include prearranged plans for transportation of injured workers and provisions for emergency medical care. At least two trained persons in every work area should have received extensive emergency training. Necessary emergency equipment, including appropriate respirators and other personal protective equipment, should be stored in readily accessible locations.

8.3 ENGINEERING CONTROLS

Engineering controls should be the principal method for minimizing exposure to respirable coal mine dust and respirable crystalline silica in the workplace. Engineering control measures include diluting the dust generated (by adequate ventilation at the coal face), controlling the respirable dust generated and entrained (e.g., with improved shearer drum design), and suppressing the dust generated (e.g., by water application).

8.3.1 Dust Control

To be effective, the dust control system in a mine should be evaluated as soon as possible after any change in geological conditions, production, processes, or controls that might increase the concentrations of respirable coal mine dust or respirable crystalline silica.

Jobs that require rock drilling (e.g., roof bolters) can generate dust containing respirable crystalline silica. Wet drills (including use of surface-active agents) or drills with attached dust collectors are advisable [Olishifski 1971; NIOSH 1992]. Dry drilling without dust controls should be prohibited. Appendix C contains further information about reducing respirable dust concentrations during overburden drilling in surface coal mining operations.

8.3.2 Ventilation

Underground coal mines are required to be mechanically ventilated [30 CFR 75.300-75.330]. The purpose of mechanical ventilation is to provide fresh air to the underground miners and to carry off toxic and explosive gases and dusts. The primary purposes of ventilation are to dilute respirable coal dust, to remove explosive concentrations of coal dust and methane from the working faces, and to remove methane from mined-out areas. In addition to supplying fresh air and exhausting noxious and explosive gases and dusts, mine ventilation systems must furnish paths of escape in the event of an underground fire. Ventilation and escape considerations relating to fire safety are extremely complex.

The portions of the mine used as part of the ventilation system are sometimes referred to as "air courses" [McAteer 1981]. Air courses are often described as follows:

- Intake air courses, which bring in fresh air to the working face
- Return air courses, which exhaust air from the working face

The number of entries available for ventilation vary with the mining method used and the geological characteristics of the rock strata mined.

Exhaust fans are commonly used to ventilate underground coal mines. Positive-pressure fans are used infrequently—usually where the mine is close to the surface and there is leakage to the surface through the air intakes. The volume of air flow through an underground mine is a function of the fan capacity and the "resistance" of the mine ventilation configuration [McAteer 1981].

Because of the multiple functions imposed on underground coal mine ventilation systems and the wide variations in underground mining methods, no general statements can be made about the availability of intake air to dilute respirable dust at the working face. Current ventilation techniques are largely dictated by regulations relating to available types of air courses, escapeway requirements, and methane regulation. The ventilation plan for each underground coal mine must be approved by MSHA [30 CFR 75.316].

Guidelines for the design of mine ventilation systems may be found in *Mine Ventilation and Air Conditioning* [Hartman et al. 1982]. Principles for the design and operation of local exhaust systems are presented in *Industrial Ventilation—A Manual of Recommended Practice* [ACGIH 1995]; *American National Standard: Fundamentals Governing the Design and Operation of Local Exhaust Systems, Z9.2 (1971)* [ANSI 1979]; and *Recommended Industrial Ventilation Guidelines*, published by NIOSH [Hagopian and Bastress 1976].

8.4 WORK PRACTICES

8.4.1 Worker Isolation

If feasible, workers should be isolated from work areas where the concentration of respirable coal mine dust or respirable crystalline silica exceeds the REL. This can be done by using automated equipment operated from a closed control booth or room. The control room should be maintained at a positive pressure so that air flows out of rather than into the room. However, personal protective clothing and equipment (including respiratory protective equipment) may be necessary when workers must perform process checks, adjustments, maintenance, or other related operations in work areas where respirable dust concentrations exceed the RELs.

8.4.2 Sanitation and Hygiene

Tobacco products should not be smoked, chewed, or carried into work areas. Workers should be provided with and advised to use facilities for showering and changing clothes at the end of each work shift. Tools and protective clothing and equipment should be cleaned as needed to maintain sanitary conditions. The work area should be kept free of flammable debris. Flammable work materials (rags, solvents, etc.) should be stored in approved safety cans.

8.5 PERSONAL PROTECTIVE EQUIPMENT

8.5.1 Protective Clothing and Equipment

Workers should wear work uniforms, coveralls, or similar full-body coverings that are laundered each day. Employers should provide lockers or other closed areas for workers to store their street clothes separately. Employers should also ensure that protective clothing is inspected and maintained to preserve its effectiveness. At the end of each workshift, employers should collect work clothing and provide for its laundering. Laundry personnel should be informed about the potential hazards of handling contaminated clothing, and they should be instructed about measures to minimize their health risk.

Workers and persons responsible for worker health and safety should be informed that protective clothing may interfere with the body's heat dissipation, especially during hot weather (e.g., in surface coal mines) or in hot work situations (e.g., in confined spaces). Additional monitoring is required to prevent heat-related illness when protective clothing is worn under these conditions [NIOSH 1986].

8.5.2 Respiratory Protection

8.5.2.1 The Need for Respiratory Protection

The need for respiratory protection in U.S. coal mines has changed considerably since 1969. The use of sophisticated extraction machines has greatly increased coal production and the quantity of dust generated. New chemicals have also been introduced for use in dust control systems, and viable biological matter has been discovered in the mining environment. Other potentially hazardous exposures include diesel exhaust, coal tar pitch volatiles from creosote-treated timbers, and polyurethane resins used in some roof support systems. The current MSHA regulations for respiratory equipment are contained in 30 CFR 70.300-70.305-1.

Engineering controls should be the primary method used to control exposures to airborne contaminants. Respiratory protection is the least preferred method of controlling worker exposures and should not be used routinely to prevent or minimize exposures. Respirators should be used by workers only in the following circumstances:

- During the development, installation, or testing of required engineering controls
- When engineering controls are not feasible to control exposures to airborne contaminants during short-term operations such as maintenance and repair
- During emergencies

8.5.2.2 Selection of Respirators

Several factors in the mine environment affect the selection of respirators. Safety factors are a particular concern, and impairment of vision must be avoided. For example, the use of water sprays to suppress dust may result in dirty water droplets that can quickly obscure vision in full-facepiece respirators. Silt can also collect around respirator face seals and irritate the skin.

The particulate filter in the respirator can become saturated and change its filtration and breathing resistance characteristics.

The *NIOSH Respirator Decision Logic* [NIOSH 1987b] should be followed to select the correct respirator. The following issues should be evaluated:

- Other available means of reducing exposure, such as increased or redirected ventilation and improved dust and vapor control systems
- The nature of the task to be performed (location, physical demands, industrial processes involved, and frequency and duration of respirator use)
- The space restrictions within the work location
- The physical nature of the air contaminant, including odor threshold, eye irritation, and other warning properties
- The interaction of contaminants with the respirator filter medium
- The concentrations of respirable coal mine dust, respirable crystalline silica, and other toxic contaminants in the miner's breathing zone
- Toxicological data, RELs, and PELs
- The required use of protective devices for the eyes and face
- The level of respiratory protection needed by the miner
- The worker's fitness to wear a respirator as determined by his or her health, potential hypersensitivity to a substance, type of respirator, fit testing, training, and conditions of respirator use (this issue is particularly important with the use of self-contained breathing apparatus)
- The performance characteristics, capabilities, and limitations of different types of respirators

8.5.2.3 Respiratory Protection Program

When respirators are used, employers should institute a complete respiratory protection program that includes, at regular intervals, worker training in the use and limitations of respirators, routine air monitoring, and the inspection, cleaning, maintenance, and proper storage of respirators. Any respiratory protection program must, at a minimum, meet the requirements of 29 CFR 1910.134. Respirators should be used according to the manufacturer's instructions.

Each respirator user should be fit-tested and the wearer's physical ability to wear a respirator should be periodically evaluated by a physician [Appendix H of NIOSH 1991b; NIOSH 1994d].

The miners should be informed annually about the hazard of dust exposure, and they should be trained in the use and care of the respirators. In addition, the program should be periodically reviewed, and if necessary, corrective action should be taken to maintain program effectiveness. For additional information about the use of respiratory protection, refer to the *NIOSH Guide to Industrial Respiratory Protection* [NIOSH 1987a] or the *NIOSH Respirator Decision Logic* [NIOSH 1987b].

Table 8-1 lists the recommended minimum respiratory protection for respirable coal mine dust and respirable crystalline silica. The *NIOSH Respirator Decision Logic* [NIOSH 1987b (or subsequent revised editions)] should be consulted if a certain condition requires a specific type of respirator other than those listed in Table 8-1.

When respirators are indicated, the employer should provide them at no cost to the worker and should assure the appropriate respirator is used. The employer should select respirators that are approved under the new NIOSH respirator certification regulation (42 CFR 84).*

8.6 EXPOSURE MONITORING

Routine environmental monitoring is an important part of an occupational health program designed to protect workers from the adverse effects of exposure to respirable coal mine dust and respirable crystalline silica. Such monitoring provides a means of assessing the effectiveness of engineering controls and work practices. The environmental monitoring (including both the initial and periodic surveys) should be conducted by competent industrial hygiene and engineering personnel. Chapter 5 and Appendices I and J contain additional information about sampling respirable coal mine dust and respirable crystalline silica.

The concentration of respirable coal mine dust or respirable crystalline silica shall be determined as a time-weighted average (TWA) by collecting samples over an 8- or 10-hr shift for up to a 40-hr workweek. For extended workshifts, Brief and Scala [1975] present a method for estimating an exposure-limit reduction factor. When the mine environment contains concentrations that exceed the REL for respirable coal mine dust or respirable crystalline silica, workers must wear respirators for protection until adequate engineering controls or work practices are instituted.

8.7 MEDICAL SCREENING AND SURVEILLANCE

First priority should be given to primary prevention of occupational respiratory diseases through the reduction of exposures. However, a secondary program of medical screening and surveillance is necessary to identify miners who develop respiratory diseases as a result of their workplace exposures. Chapter 6 contains provisions for preplacement and periodic medical examinations and recommendations for medical intervention.

*42 CFR 84 became effective July 10, 1995, and replaces the provisions under 30 CFR 11.

Table 8–1. NIOSH-recommended respiratory protection for workers exposed to respirable coal mine dust and respirable crystalline silica

Condition	Airborne concentration (mg/m^3)*		Minimum respiratory protection
	Respirable coal mine dust	Respirable crystalline silica	
Entry into environments containing respirable dust	≤1 (1 × REL)†,‡	≤0.05 (1 × REL)	No respirator required
	≤5 (5 × REL)	≤0.25 (5 × REL)	Single-use or quarter-mask respirator equipped with any type of particulate filter§
	≤10 (10 × REL)	≤0.5 (10 × REL)	Any air-purifying, half-mask respirator equipped with any type of particulate filter,§ or
			Any supplied-air respirator equipped with a half mask and operated in a demand (negative-pressure) mode
	≤25 (25 × REL)	≤1.25 (25 × REL)	Any powered, air-purifying respirator equipped with a hood or helmet and any type of particulate filter,§ or
			Any supplied-air respirator equipped with a hood or helmet and operated in a continuous-flow mode
	≤50 (50 × REL)	≤2.5 (50 × REL)	Any air-purifying, full-facepiece respirator equipped with a high-efficiency filter,§ or
			Any powered, air-purifying respirator equipped with a tight-fitting facepiece and a high-efficiency filter,§ or
			Any supplied-air respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode, or
			Any supplied-air respirator equipped with a tight-fitting facepiece and operated in a continuous-flow mode, or
			Any self-contained respirator equipped with a full facepiece and operated in a demand (negative-pressure) mode
	≤500 (500 × REL)**	≤25 (500 × REL)	Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode

(Continued)

See footnotes at end of table.

Table 8–1 (Continued). NIOSH-recommended respiratory protection for workers exposed to respirable coal mine dust and respirable crystalline silica

Condition	Airborne concentration (mg/m^3)*		Minimum respiratory protection
	Respirable coal mine dust	Respirable crystalline silica	
Planned or emergency entry into environments containing respirable dust	>500 (500 × REL) or unknown concentrations	>25 (500 × REL) or unknown concentrations	Any self-contained breathing apparatus equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode, or Any supplied-air respirator equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure-demand or other positive-pressure mode
Firefighting	——	——	Any self-contained breathing apparatus equipped with a full facepiece and operated in a pressure-demand or other positive-pressure mode
Escape only	——	——	Any air-purifying, full-facepiece respirator with a high-efficiency filter,§ or Any appropriate escape-type, self-contained breathing apparatus or self-contained self rescuer (SCSR)

*The highest measured concentration of respirable coal mine dust or silica determines the minimum respiratory protection to be supplied to and worn by the miner.
†Assigned protection factor (APF) times the NIOSH REL. The APF [NIOSH 1987b] is the minimum anticipated level of protection provided by each type of respirator.
‡The values in this table were computed using the NIOSH REL of 1 mg/m^3 for respirable coal mine dust measured according to current MSHA methods (see Section 5.1). This REL of 1 mg/m^3 is equivalent to 0.9 mg/m^3 when measured according to the international definition of respirable dust (see Sections 5.2 and 5.4).
§The new NIOSH respirator certification regulation (42 CFR 84) became effective July 10, 1995, and replaces the old regulation (30 CFR 11). High-efficiency is the appropriate filter for respirable crystalline silica under 30 CFR 11; N100, R100, and P100 are the appropriate filters for respirable crystalline silica under 42 CFR 84.
**For airborne particulates, 500 × REL is the concentration above which only the most protective respirators are recommended [NIOSH 1994a].

8.8 SMOKING CESSATION

Overwhelming evidence exists for the adverse health consequences of smoking, the number of workers affected, and the additive effects of smoking and dust exposures on the development of occupational respiratory diseases (e.g., chronic bronchitis, emphysema, and lung cancer). Because of this evidence, NIOSH and the Association of Schools of Public Health cosponsored a *Proposed National Strategy for the Prevention of Occupational Lung Diseases*, which recommended the elimination of smoking in the workplace as an important strategy for preventing occupational lung diseases [ASPH 1986]. The recommendation was further supported by the NIOSH conclusion that nonsmokers exposed to environmental tobacco smoke[†] in the workplace had an increased risk of lung cancer [NIOSH 1991a].

NIOSH recommends the following regarding smoking in the workplace:

- Workers should be prohibited from smoking in the workplace.
- Information about health promotion and the harmful effects of smoking should be disseminated.
- Smoking cessation classes should be offered to workers at no cost to the participant.

Therefore, in addition to the MSHA prohibition of smoking in all underground mines and in surface mines where fire or explosion may result [30 CFR 75.1072 and 77.1711], NIOSH recommends that smoking be prohibited in all underground and surface coal mines and all other work areas associated with coal mining to prevent exposure to environmental tobacco smoke, a potential occupational carcinogen [NIOSH 1991a]. NIOSH also recommends that all miners who smoke participate in a smoking cessation program.

8.9 RECORDKEEPING

Medical records must be maintained for workers as specified in Section 1.11 of this document. They must be kept for at least 40 years after termination of employment. Copies of environmental exposure records for each worker must be included with the medical records. These records must be made available to past or present workers or to anyone having the specific written consent of a worker, as specified in 42 CFR 37.80.

8.10 PROTECTING CONTRACT MINERS

Some provisions of the standard recommended in this criteria document may be difficult to apply to a special category of miners known as contract miners. Coal miners who are contracted to work on specific jobs at various mines for relatively short periods may not gain the full benefits of exposure monitoring, medical surveillance, hazard training, and transfer programs normally available to other mine workers. NIOSH recognizes the need to include these contract miners in a recommended standard and will continue to explore options that will address their occupational safety and health needs.

[†]Environmental tobacco smoke is tobacco smoke in the ambient atmosphere composed of sidestream smoke and exhaled mainstream smoke [NIOSH 1991a].

9 RESEARCH NEEDS

Additional research and data analysis are needed for improvements in engineering control methods, respiratory protection, sampling devices and strategies, medical screening and intervention, adverse health effects of dust exposure, characterization of dust for future recommended standards, and training and education. The following is a list of such research needs:

Engineering control methods

- Assess current control technology in the coal mining industry by examining state-of-the-art technologies and work practices.
- Develop and recommend improved methods for keeping worker exposures below the RELs for respirable coal mine dust and respirable crystalline silica in underground and surface coal mines.

Respiratory protection

- Evaluate the physiological stress placed on miners who must wear respiratory protection.

Sampling devices

- Develop sampling devices with improved design for greater accuracy and precision and more rugged construction.
- Develop continuous monitors for use in sampling respirable coal mine dust.

Sampling strategy

- Evaluate sampling strategies for the accurate monitoring and control of worker exposures.
- Evaluate sampling strategies for effective enforcement of the standard.

Medical screening and intervention

- Evaluate the effectiveness of the existing transfer program in preventing the progression of simple CWP. The transfer program enables miners with CWP category 1/0 or greater

to transfer to jobs in areas of the mine where mean concentrations of respirable coal mine dust are 1 mg/m^3.

- Identify early markers of disease to help identify adverse health effects of exposure to respirable coal mine dust and respirable crystalline silica and to prevent or impede disease progression.

- Determine the factors affecting the incidence of PMF in miners without prior radiographic evidence of simple CWP. Determining these factors will facilitate early identification and intervention.

- Evaluate exposure-response relationships affecting lung function in surface coal miners.

- Evaluate the effectiveness of reducing or eliminating exposures to respirable coal mine dust (and tobacco smoke, if applicable) in halting or impeding decline in lung function.

- Determine the prevalence of miners who have normal spirometry values and chest X-rays but abnormal gas exchange values. Knowledge of this prevalence would help determine the need for lung function tests in addition to spirometry tests (FEV_1 and FVC): DLCO or transcutaneous measurements of arterial oxygen pressure, for example.

Adverse health effects of dust exposure

- Investigate exposure, dose, and response relationships—including the effect of exposure patterns (intensity and duration) on the development of occupational respiratory diseases in coal miners.

- Assess the influence of dust composition and characteristics (e.g., quartz concentration, thoracic dust) on the development of simple CWP, PMF, and COPD in coal miners.

- Evaluate the role of overloaded lung clearance mechanisms in the development of occupational respiratory diseases in coal miners.

- Evaluate the ways in which the statistical model may affect risk estimates for occupational respiratory diseases—particularly in the low-exposure regions of the exposure-response curves.

- Analyze the relationship between exposure to thoracic coal mine dust and COPD.

Characterization of dust

- Compare the particle size distribution and the composition of airborne respirable dust in underground coal mines, surface mines, and other worksites where workers are exposed to coal dust.

Training and education

- Determine the training and education needed to promote occupational safety and health awareness in coal miners and coal mine operators, including safe work practices and use of engineering controls and personal protective equipment.